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TEST RESULTS FOR NEW OI OPERATIONAL ANALYSIS

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1. Introduction:

The optimum interpolation (OI) method for objective analysis has been used for five years in the NMC global data assimilation system. In this note, we review the results of a test of the OI method in which it was applied to the production of global, medium-range numerical weather predictions. The test was conducted to gain assurance that the method would produce satisfactory depictions of the meteorological state of the atmosphere and also provide suitable initial conditions for the production of global numerical forecasts. The test results supported the decision to implement the method as the new operational analysis system on July 18, 1984, in place of the Hough analysis method.

The test was conducted during the period May 1 to June 8, 1984. It involved the daily production of analyses and forecasts based on the OI analysis method. All tests were made for the 0000 GMT synoptic cycle, since that initial time permitted the experimental runs to proceed without affecting the routine operational production.

The forecasts were produced daily to 60 hours; every other day, the forecast was extended to 240 hours. Some few test runs were incomplete due to computer difficulties that were unrelated to the analysis or forecast programs.

Objective comparisons were made with radiosonde and aircraft observational data for the analysis, 24 hour and 48 hour forecasts. Medium-range forecasts were evaluated subjectively by meteorologists in NMC's Forecast Division. The shorter range output was also examined by NMC's Forecast and Development Division staff. The 204 hour 500 mb forecasts for North America were evaluated objectively.

Objective Verification

Three different objective verification programs were used to evaluate the comparative performance of the test "OI" and operational "Hough" analyses, and of the forecasts produced from them by the global spectral model.

The first of these programs ("SUMAC") validates the analysis and the 24-hour and 48-hour forecasts against observations made by radiosondes. Three mutually exclusive radiosonde networks were employed: 37 stations covering western North America, 73 stations covering eastern North America, and 96 stations covering Europe.

The other two programs were designed to verify 24-hour jet aircraft flight-level wind forecasts. One code ("MM") was highly selective in choosing only aircraft observations made within +/- one hour of the forecast's valid time and located between 300 and 200 mb pressure altitude. It distinguished three routes: one across the North Pacific, one along the path between California and Hawaii and the third along the North Atlantic flight path.

The second aircraft verification code ("DES") assumed the flight level to be near 250 mbs. It verified the 24-hour forecast vector wind against observations in two large areas: Atlantic (72 1/2°W to 7 1/2°W) and Pacific (227 1/2°W to 122 1/2°W). Both regions extended over the entire northern hemisphere.

2.a. SUMAC - Analysis

The fit of the analysis to observations was calculated for each network at four pressure levels: 850, 500, 250 and 100 mbs. In Table 1 the root-mean-square "error" in the geopotential height, temperature and vector wind is presented for the entire collection. Note that the root-mean-square vector wind error is defined by

$$RMSVE = [\overline{(Ue^2 + Ve^2)}]^{1/2}$$

where Ue and Ve are the errors in each component of the wind, and the bar denotes the average over the ensemble of cases. In Table 1 the networks of stations are abbreviated WNA, ENA and EUR, for western and eastern North America and Europe. The scores for the 'Hough' analyses are in the columns headed by H; the scores for the 'OI' analyses are in the columns headed by O.

The tabulated statistics were accumulated during the period 5/1 to 6/8 1984 using the 0000 GMT cycle only. Some four days were missed durng the month of May due to machine problems. It may be noted that the temperature is not directly analyzed but is derived from the analyzed geopotential height using the same procedure for both analysis systems.

The differences between the scores for the two analysis methods are small; for the most part, the differences lie well within the limits of uncertainty of observational error. When augmented by subjective evaluation of the maps, it may be concluded that the OI analysis draws more closely for the wind maxima in jets. This is an expected result due in part to the greater horizontal resolution of the OI scheme.

2.b. SUMAC Forecasts:

In Tables 2 and 3, one may find the verification of 24 and 48 hour forecasts against radiosonde data for the test period. The format of these tables is identical to that of Table 1. The column headed by the letter H contains the scores achieved by forecasts starting from the Hough analysis; the column headed by the letter O has scores computed for forecast that began with data based on the OI analysis.

In aggregate, the statistical differences between the two sets of forecasts is small. One may note, however, that there is some evidence that the OI-based forecasts are superior to the Hough-based forecasts over the area represented by the western North America network. At 500 and 250 mb, the (OI-based) 48 hour forecasts seem to be slightly more accurate over all three verification networks.

ANALYSIS

		WNA		ENA		EUR	
		H	O	H	O	H	O
	Z	14.5	11.9	9.2	7.5	9.0	8.2
850	T	2.3	2.5	2.0	2.2	1.7	1.5
	V	4.7	4.5	4.9	3.8	4.8	4.5
	Z	12.0	9.3	11.4	9.9	15.1	14.5
500	T	1.1	1.1	1.1	1.1	1.1	1.1
	V	4.7	4.3	4.8	4.5	5.2	5.3
	Z	14.4	14.4	15.5	14.9	24.3	24.5
250	T	1.8	1.3	1.6	1.2	2.4	2.0
	V	6.5	5.7	7.2	6.3	7.3	7.1
	Z	33.0	33.5	26.8	26.8	38.8	37.9
100	T	1.8	1.8	1.4	1.5	1.3	1.4
	V	2.9	3.4	3.3	3.7	3.3	3.4

Table 1

24 HOUR FORECASTS

		WNA H	WNA O	ENA H	ENA O	EUR H	EUR O
	Z	31.7	31.8	20.3	18.7	19.6	20.0
850	T	5.3	5.0	2.6	2.7	1.9	2.0
	V	5.9	6.2	5.5	5.5	5.7	5.9
	Z	34.2	30.0	23.6	24.5	28.8	29.4
500	T	1.9	1.7	1.5	1.5	1.6	1.6
	V	7.2	7.0	6.7	6.3	7.3	7.5
	Z	44.0	37.9	32.0	33.3	41.6	43.7
250	T	2.2	2.3	1.9	1.8	2.8	2.9
	V	10.9	10.3	10.1	10.0	10.1	10.4
	Z	41.2	43.2	34.7	34.7	46.4	50.1
100	T	2.3	2.2	2.0	2.1	1.7	1.6
	V	6.3	7.4	5.9	6.5	4.8	4.9

Table 2

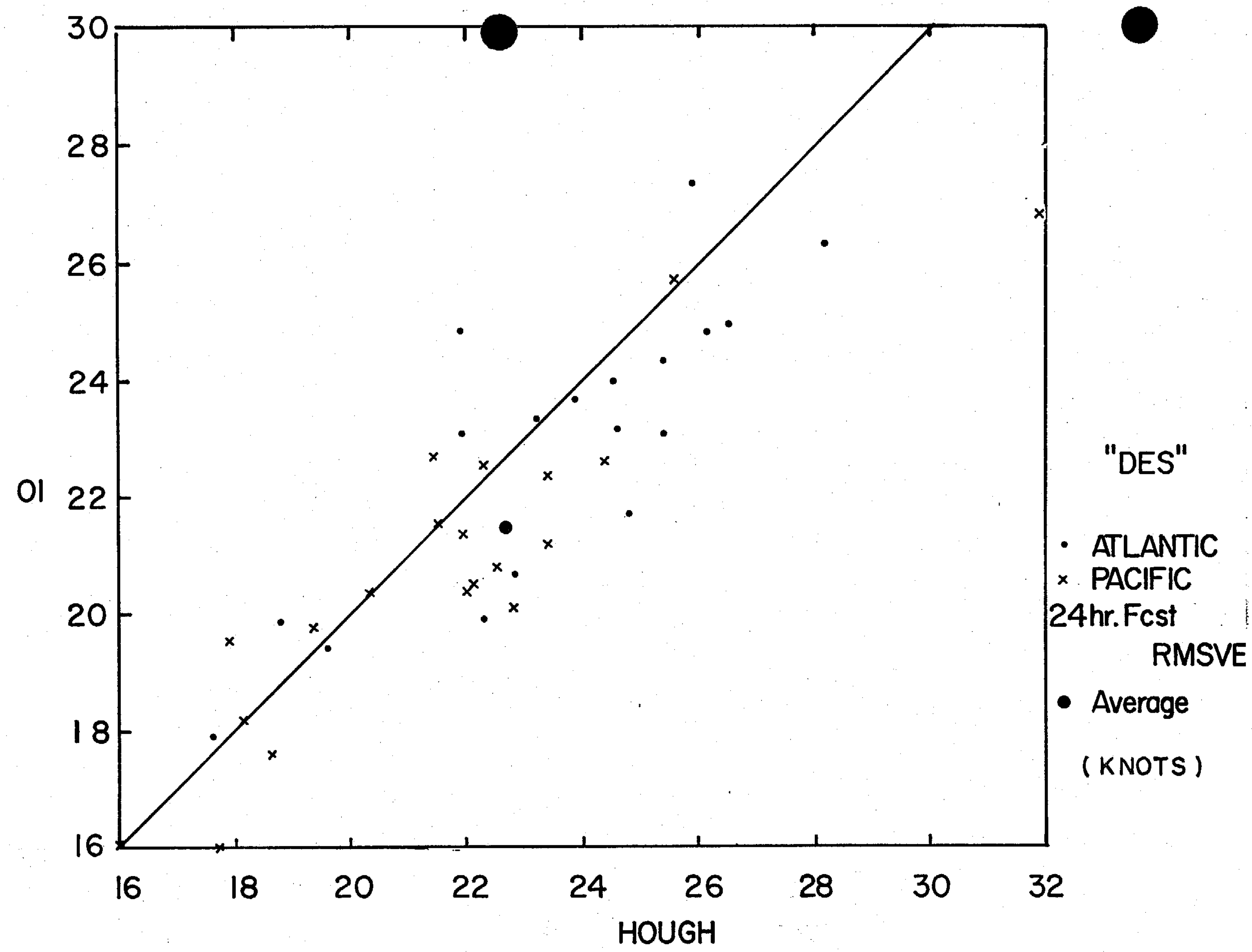
48 HOUR FORECASTS

		WNA H	WNA O	ENA H	ENA O	EUR H	EUR O
	Z	46.2	44.6	31.5	30.5	33.8	33.1
850	T	6.8	6.6	3.6	3.6	2.7	2.6
	V	6.9	7.0	7.3	7.6	7.4	7.2
	Z	47.4	45.3	38.3	38.5	46.3	44.6
500	T	2.4	2.3	2.2	2.1	2.3	2.3
	V	9.2	9.0	8.3	8.4	9.5	9.7
	Z	63.9	63.0	58.4	54.3	67.2	66.7
250	T	2.9	3.0	2.3	2.3	3.4	3.8
	V	14.5	14.3	13.3	13.1	14.3	14.1
	Z	53.3	56.5	42.6	41.6	55.5	60.9
100	T	2.6	2.9	2.5	2.3	1.9	1.9
	V	8.2	9.1	7.2	7.9	5.8	6.0

Table 3

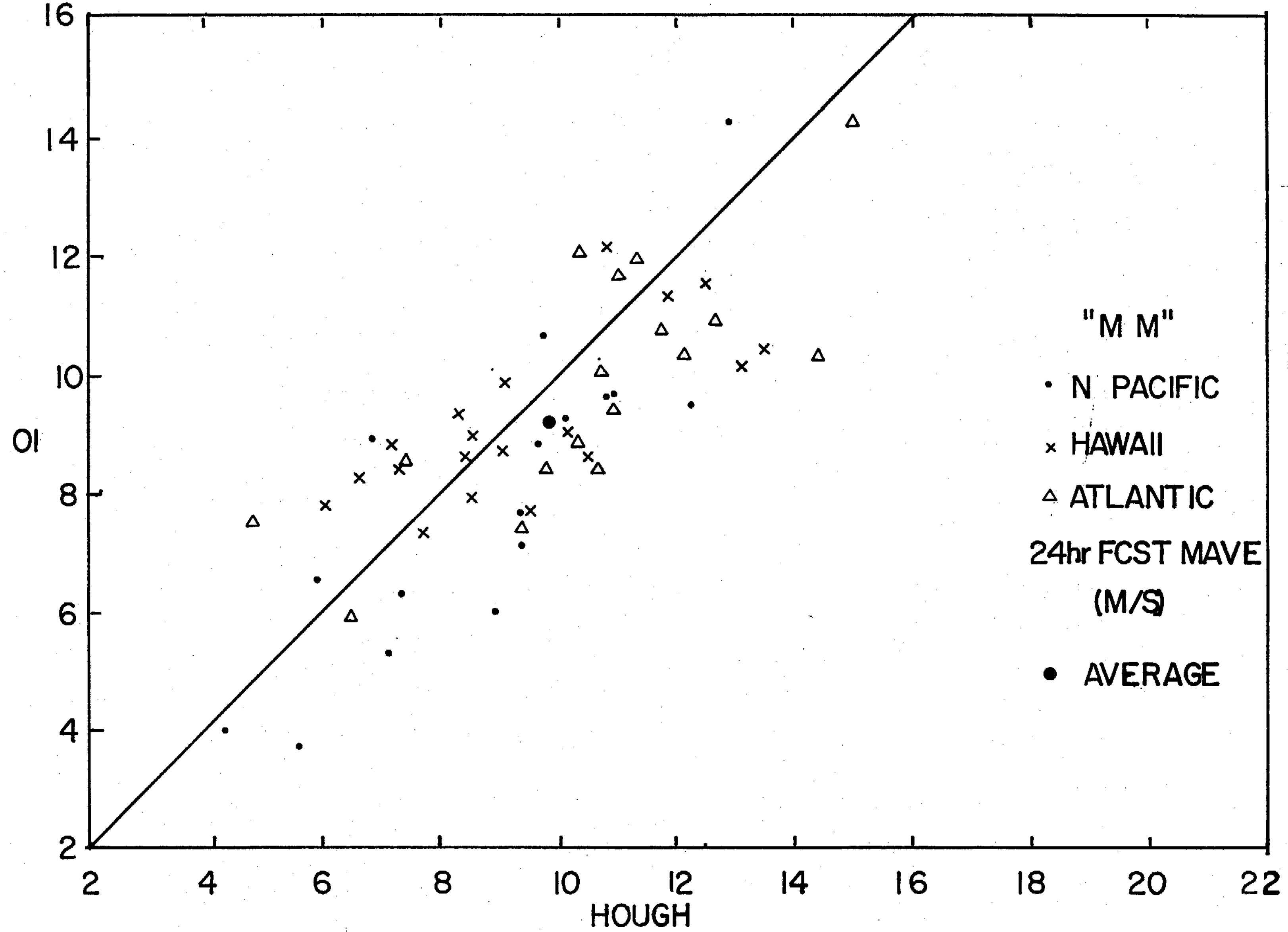
2.c. Aircraft Wind

The results of the verification of 24 hour aviation wind forecasts made during May are depicted in Figures 1 and 2. These scatter diagrams make evident the dispersion of the day-by-day results. Only in the aggregate, does the OI-based forecast wind emerge as being more accurate.



30
28
26
24
22
20
18
16
OI
16
18
20
22
24
26
28
30
32
HOUGH
"DES"
ATLANTIC
PACIFIC
24hr. Fcst
RMSVE
Average
(KNOTS)

Fig 2



16
14
12
10
8
6
4
2
OI
2
4
6
8
10
12
14
16
18
20
22
HOUGH
"M M"
N PACIFIC
HAWAII
ATLANTIC
24hr FCST MAVE
(M/S)
AVERAGE

Fig 1

3. Longer-range Forecasts:

The global forecast model provides the principal machine guidance for the medium-range forecast group of the NMC Forecast Division. As part of the evaluation of the impact of the change to the OI analysis method both 4 1/2 and 8 1/2 day forecast maps were produced for approximately one-half of the experimental cases. A total of 21 108-hour forecasts and 16 204-hour forecasts were successfully completed. Scheduling or machine problems caused the unevenness of these data sets.

Both the 4 1/2 and 8 1/2 day forecasts were evaluated subjectively in comparison with the operationally produced forecasts. Focus of the evaluation was upon North America. In the longer-range only the low wave number component of the 500 mb field was examined. At 4 1/2 days both mean sea level pressure and 500 mb height fields were evaluated.

For the 204-hour forecasts the anomally correlation statistic was also computed.

One must recognize that forecast skill is significantly degraded by 4 1/2 days. Judging which of two relatively poor forecasts is more accurate is a tenuous decision. At 108 hours, the subjective evaluation of 21 cases gave the results:

108 Hr.	Subjective Evaluation
MSLP	OI better 7; tied 1; Hough better 13
500 mb	OI better 7; tied 4; Hough better 10

For the 204 hour forecasts (16 cases), the results were:

204 Hr.	Subjective Evaluation
500 mb	OI better 7; tied 3; Hough better 6

The anomally correlation calculated for the 8 1/2 day forecasts had the average values: OI - 16.5; Hough - 21.8. On the average these forecasts possess marginal utility as guidance for experienced forecasters. There is, however, a considerable variation in the skill of individual forecasts which makes it difficult to assess the statistical advantage associated with the different methods for initial analysis.

4. Synoptic Characteristics

The shorter range forecasts were reviewed by experienced forecasters in order to determine whether or not characteristic differences might be observed in the analyses and forecasts. The general conclusion from these investigations was summarized by H. Saylor who stated, in effect, that a forecaster could not readily distinguish one analysis or forecast series of isobaric charts from the other.

D. Olson, who examined the precipitation forecasts and synoptic charts through 60 hours, concluded that, "In general, there does not seem to be a whole lot of significant difference between the two systems." R. McCarter noted that the OI-based jet maxima were sometimes stronger than those resulting from the Hough analysis and in a few cases gave rise to unusually strong tropopause wind shears.

In a daily examination of the forecast charts, a tendency was noted for OI-based forecasts to produce somewhat more vigorous cyclones over the Pacific. In a few cases, the OI analysis produced superior forecasts of small-scale cyclones reaching the coast of Washington state. East of the Rocky Mountains, the thermal ridge ahead of surface cyclones had some tendency to be slightly more intense than those forecast operationally. As noted by D. Olson, this feature was not systematically in the right direction.

It is anticipated that the small impact of the transition to the OI analysis system will not adversely affect the overall quality of the numerical forecast guidance.

5. Bibliography

For the reader who wishes to know more about the optimum interpolation method for objective analysis reference may be made to the following:

Lorenc, A. C., 1981: A Global Three-Dimensional Multivariate Statistical Interpolation Scheme. Monthly Weather Review, 109, 701-721.

Kistler, R. E., and D. F. Parrish, 1982: Evoluation of the NMC Data Assimilation System: September 1978-January 1982. Monthly Weather Review, 110, 1335-1346.

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